Latest top results from CDF

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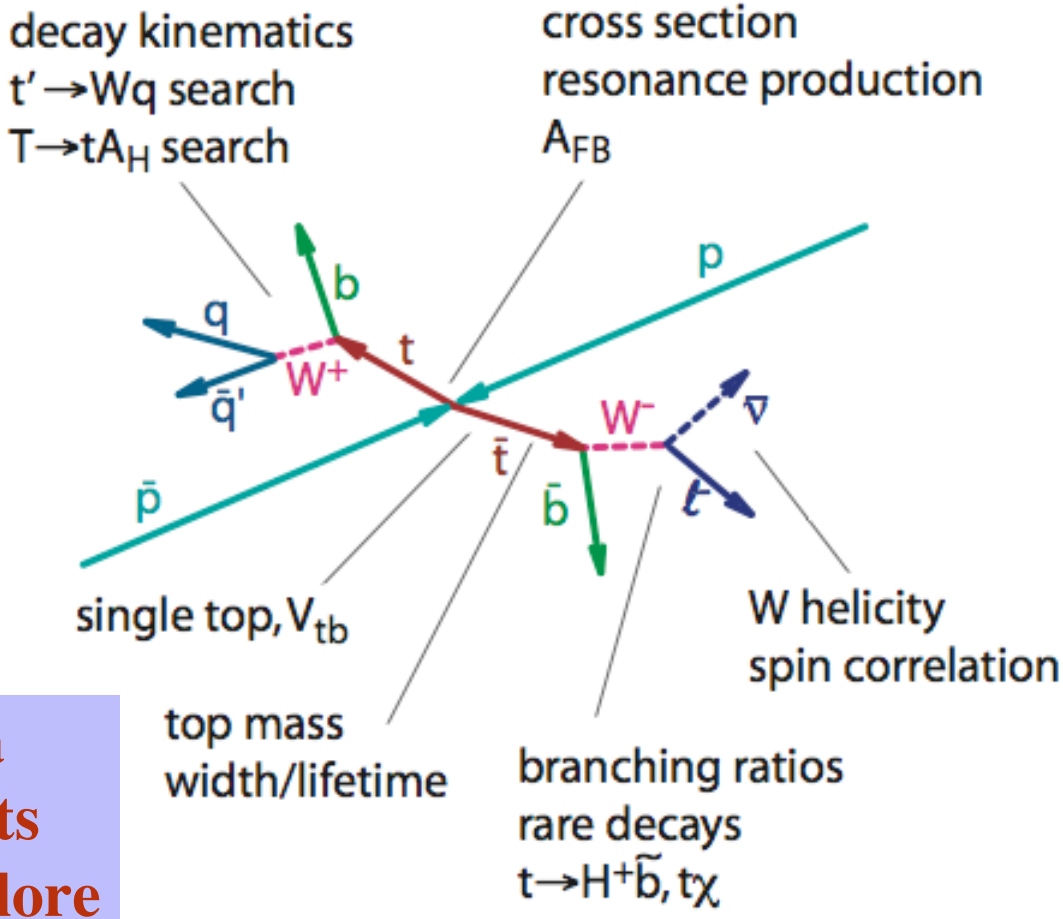
for the CDF collaboration

Top quark

Huge mass,short lifetime: decays before hadronizing

Special role in EWSB?

Probes physics at highest allowable mass scale



Top physics is mature for a wide range of measurements which we just began to explore

Top pair decays

Lepton+Jets

golden channel: high statistics *AND* good S/B ratio. Most of the measurements are made here

All hadronic

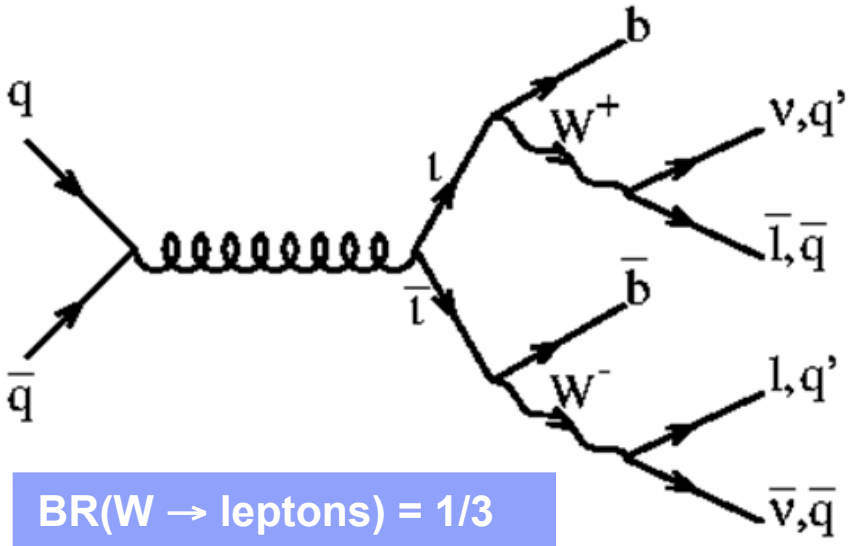
challenging channel: highest statistics *BUT* huge backgrounds

Dileptons

cleanest sample even before b-tag *BUT* lowest statistics & neutrinos

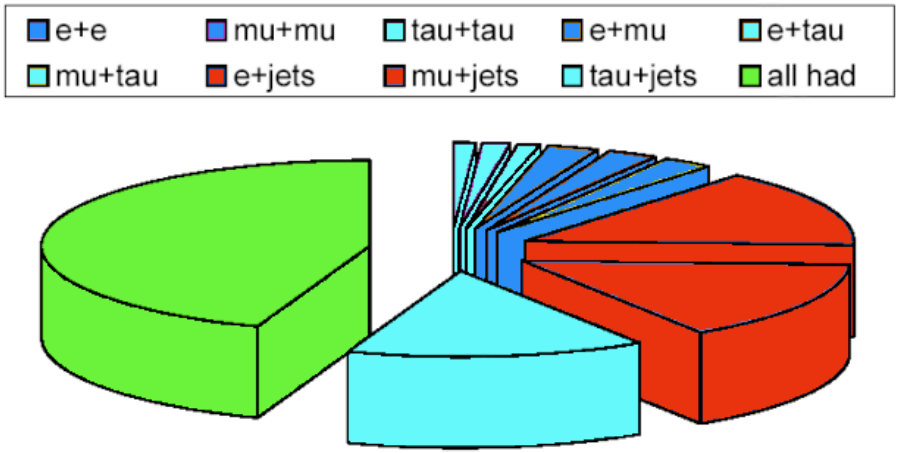
MET+jets

large acceptance to taus, orthogonal to others



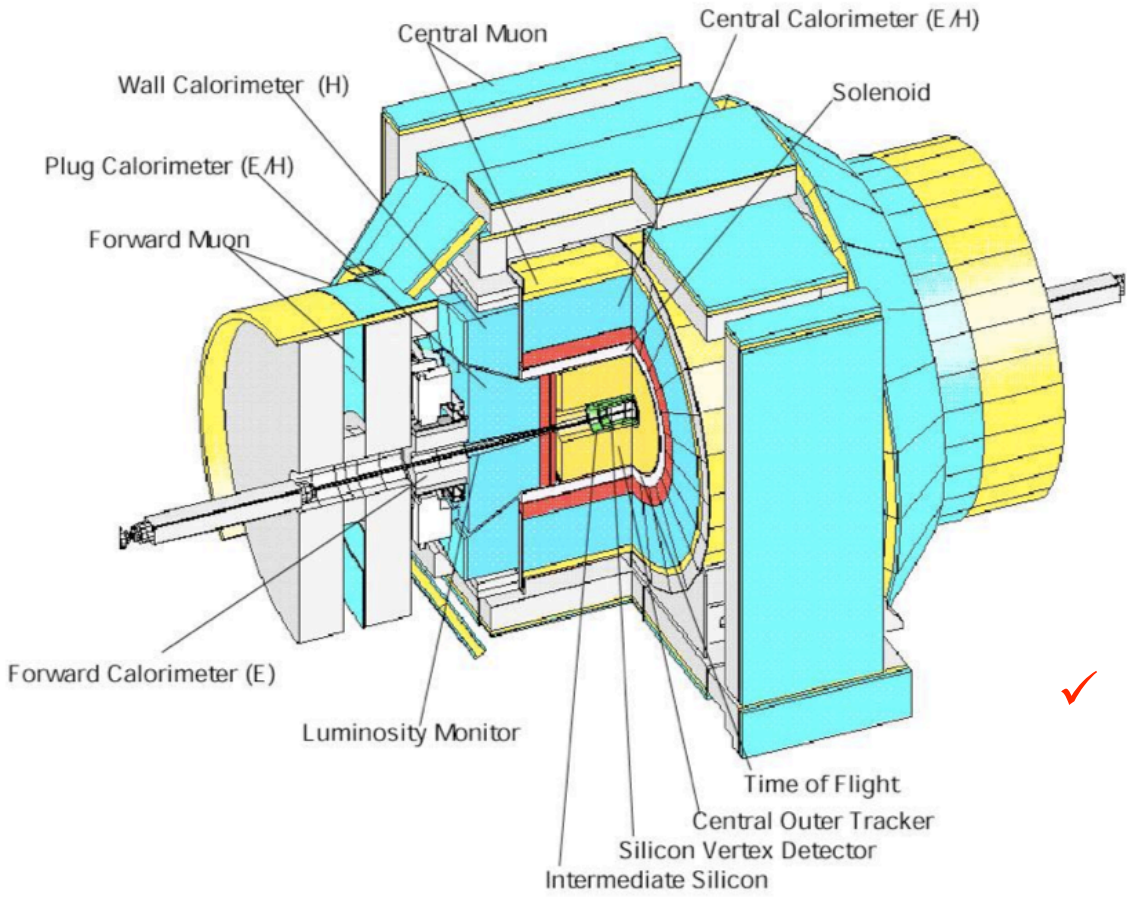
BR(W → leptons) = 1/3
BR(W → quarks) = 2/3

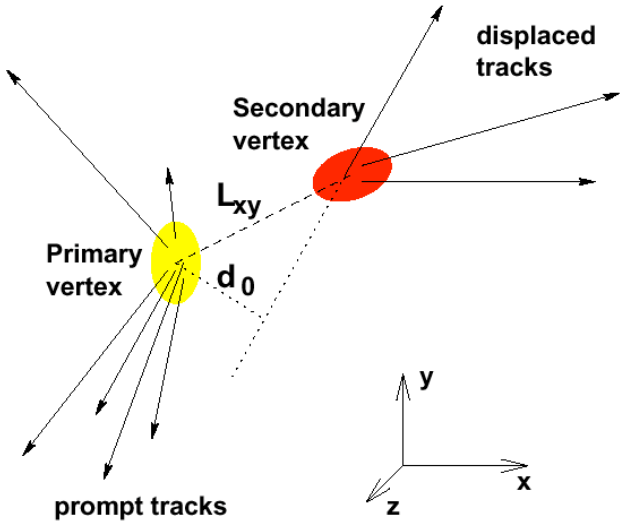
ttbar Decay Modes



CDF detector

- ✓ **Tracking: silicon tracker - drift chamber**
  - muon chambers

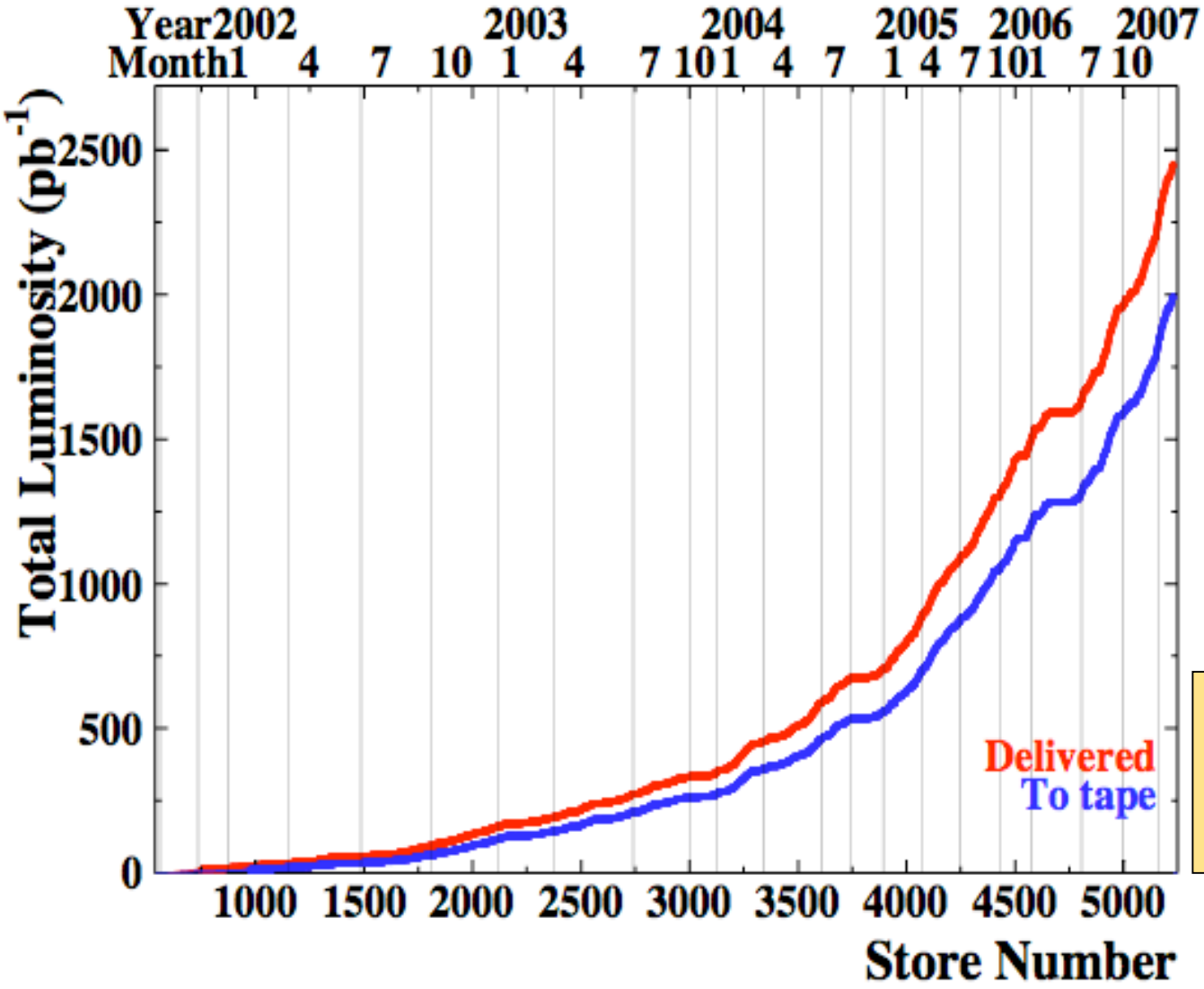




- ✓ **b-quark identification w silicon detector (SVX)**
  top event b-tag eff: ~ 55%

- ✓ **Calorimeters:**
  central, wall, plug
  overall coverage: $|\eta|<3.6$

Luminosity



2.5 fb^{-1} delivered

2.0fb^{-1} on tape

up to 1.0 fb^{-1} used in the following analysis

Common features

Trigger requirements	
L+jets	inclusive high Et lepton (e/μ)
Dilepton	
All-jets	high jet multiplicity & $SumE_T$>175GeV
ME_T+jets	

Event selection	
L+jets	$P_T(e/\mu) > 20GeV$ large ME_T $E_T(jets) > 15GeV$
Dilepton	As above with 2 high P_T leptons
All-jets	≥6 jets + NN selection + b-tag OR cut-based selection + b-tag
ME_T+jets	As above but large ME_T significance

Main Backgrounds	
L+jets	W+jets (b's, c's, others), QCD (jets faking leptons)
Dilepton	$Z/\gamma^* \rightarrow l^+l^-$, diboson
All-jets	QCD multijet
ME_T +jets	QCD/W+jets

Cross section

Tests QCD in high Q^2 regime

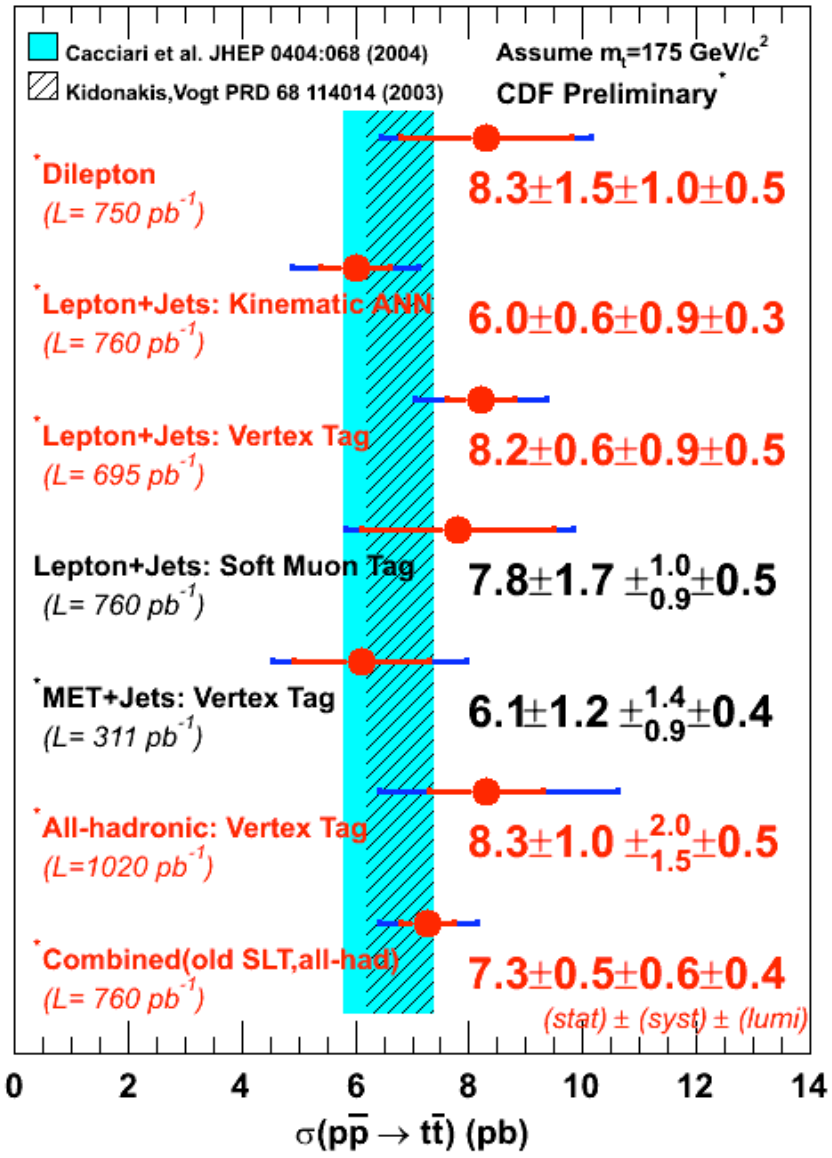
Each channel is sensitive in a different way to new physics

Study of sample composition (useful for other property measurements)

Most measurements are counting experiments:

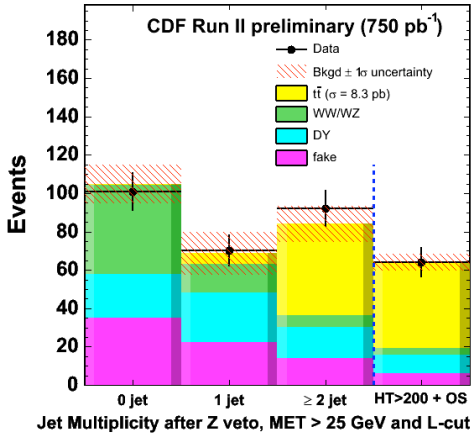
$$\sigma_{t\bar{t}} = \frac{N_{obs} - N_{bkg}}{A \times \int \mathcal{L} dt}$$

No discrepancies found



Some x-sec measurements

Counting experiment



Dilepton

Background modeling: MC + data-driven

no b-tag

result with 750pb^{-1}

σ_{tt}= 8.3±1.5(stat.)±1.0(syst.)±0.5(lum.) pb

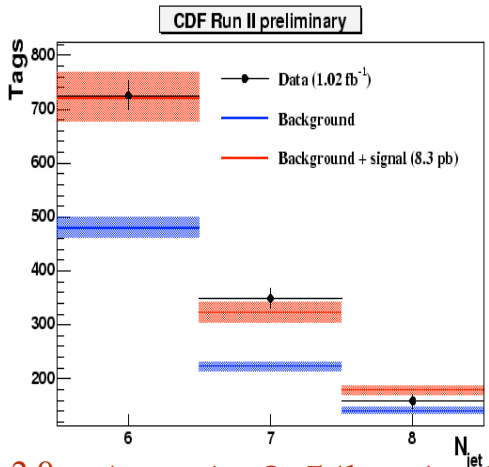
Alljets

NN + b-tag

S/B~1/2 high

acceptance 5%

result with 1.0fb^{-1}



σ_{tt}= 8.3±1.0(stat.)$^{+2.0}_{1.5}$(syst.)±0.5(lum) pb

Likelihood fit

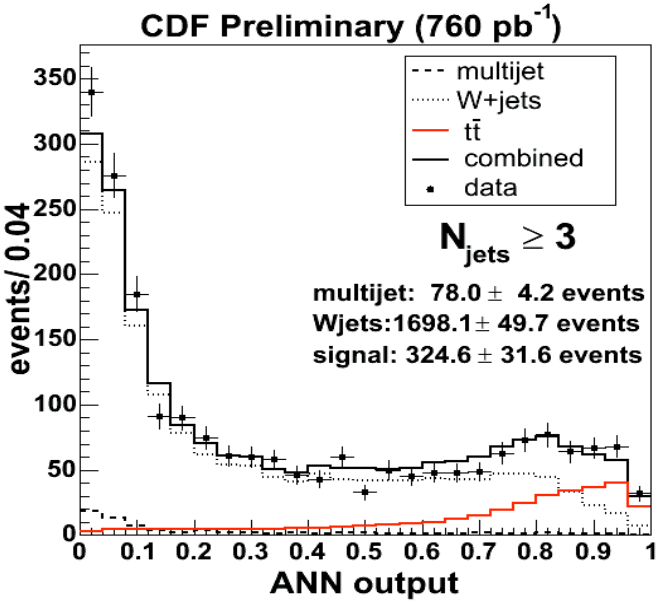
L+jets

NN w/o b-tagging requirement:

larger acceptance ~ 300 tt evts

but larger background -> fit shapes

result with 760pb^{-1}



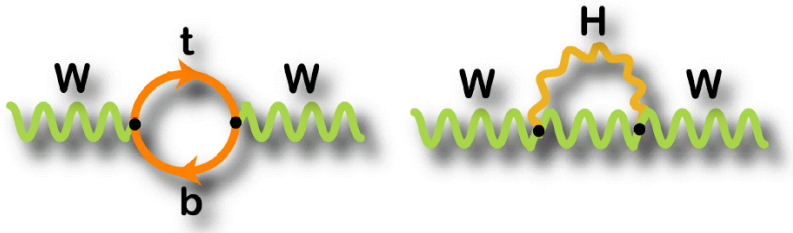
σ_{tt}=6.0 ± 0.6 (stat.) ± 0.9 (syst.) pb

Top mass

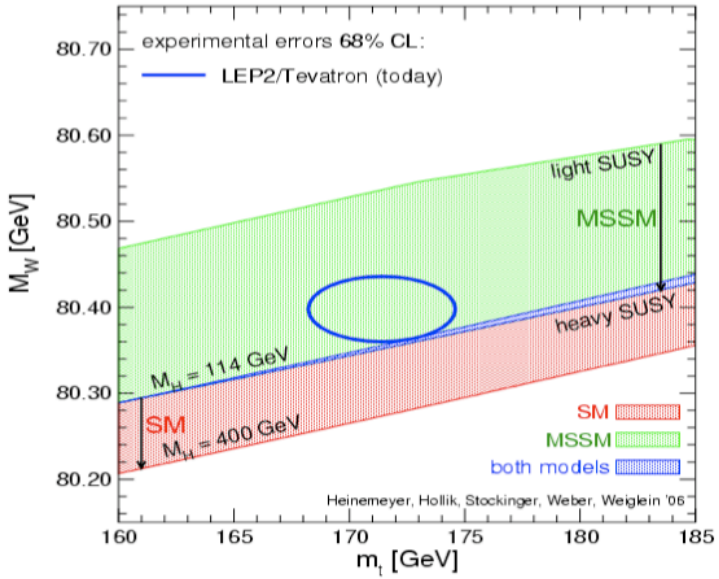
Fundamental parameter in the SM

M_{top} enter in radiative corrections:

$\Delta M_W \propto M_{top}^2$ $\Delta M_W \propto \ln M_H$

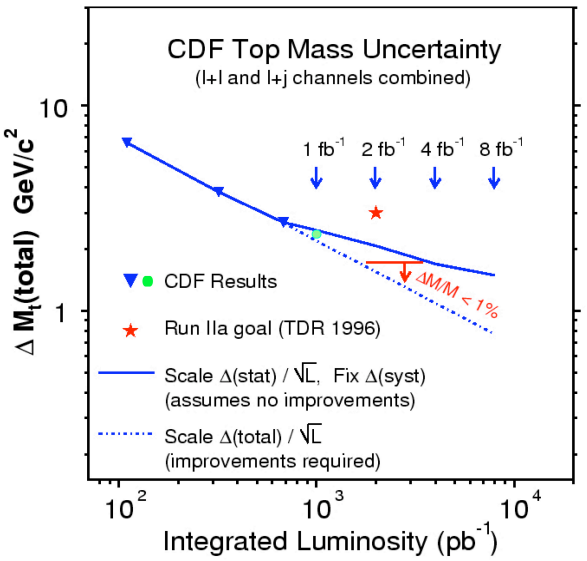


Together with M_w it constrains M_{Higgs}



RunII design goal: 2-3 GeV O(10 fb^{-1})

RunII 1fb results : ~2GeV with just 1 fb^{-1}



- Different challenges in different channels:

(low statistics,high background,combinatorics)

Lots of measurements!

Top mass measurement at CDF's:

large number of measurements using all 4 signatures

different techniques:

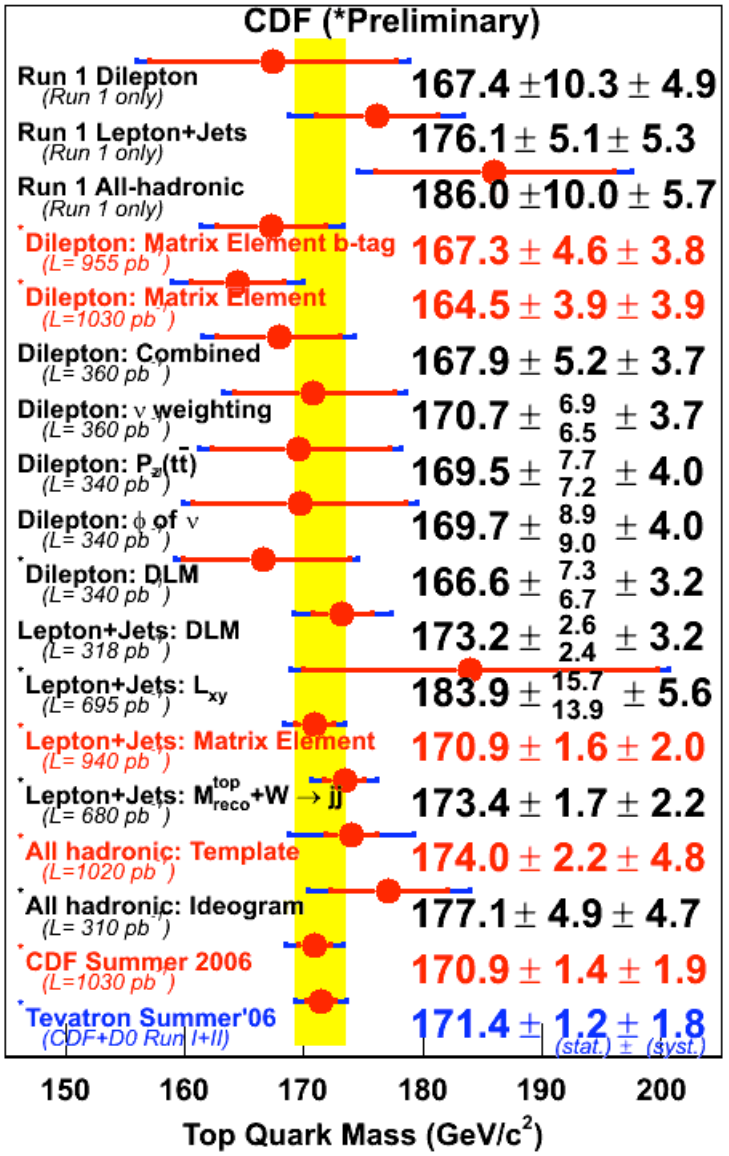
Template method

Matrix Element

Not all of them are shown!!!

Latest CDF combination:

m_{top}=170.9 ± 1.4 ± 1.9 GeV/c^2

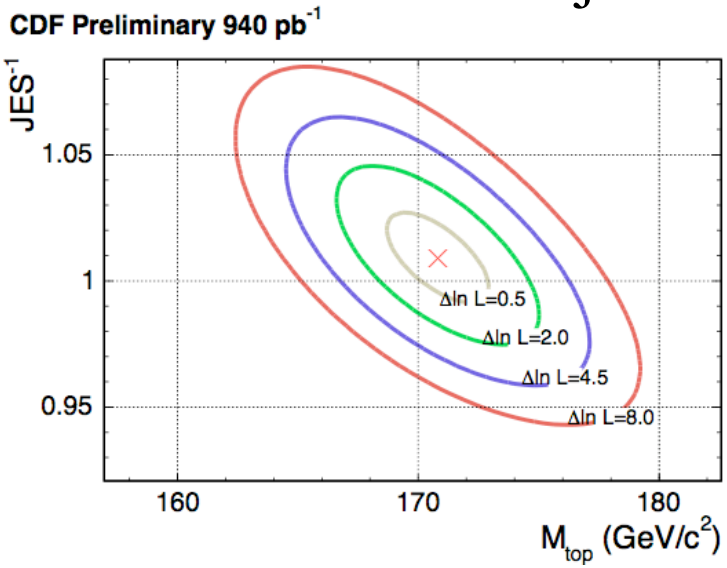


Lepton+jets

Matrix element technique

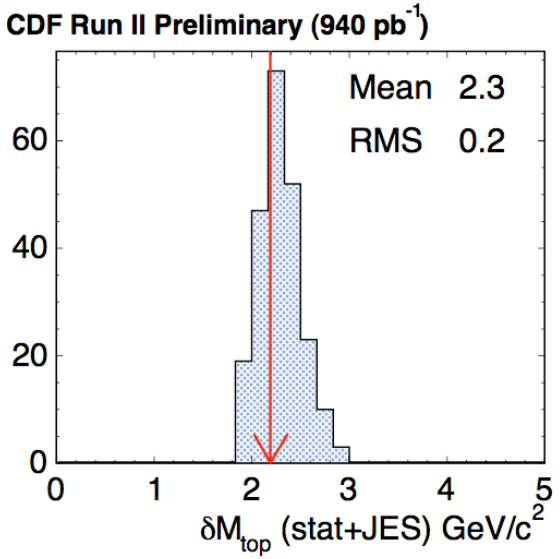
$$\mathcal{L}(M_{top}, JES, C_s; \vec{x}) \propto \prod_{i=1}^{N} [C_s P_{t\bar{t}}(\vec{x}; M_{top}, JES) + (1 - C_s) P_{W+\text{jets}}(\vec{x}; JES)]$$

Jet Energy Scale (JES) measured through a contraint of the untagged dijets mass to known W mass



S/B~1/2

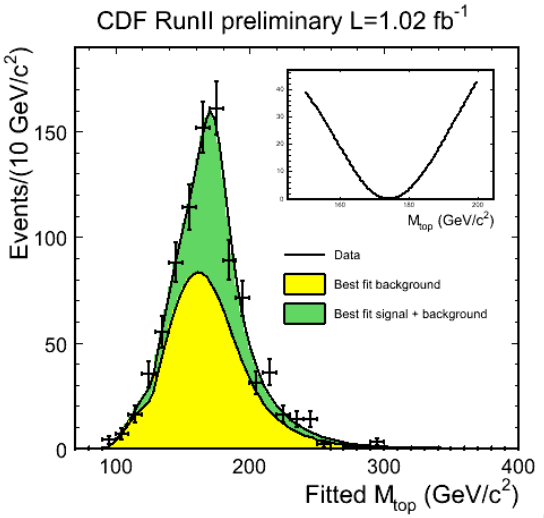
N_S~100evts



M_{top} = 170.9 ± 2.2 (stat+JES) ± 1.4 (syst) GeV/c^2

Most precise single measurement in the world!

All hadronic channel



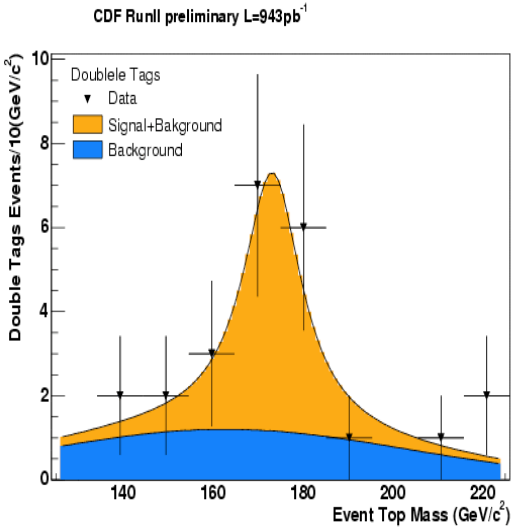
Template method

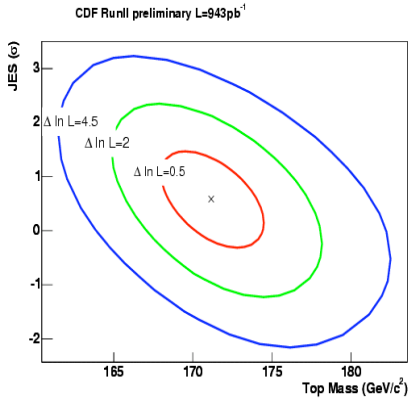
NN kin selection + b-tag S/B~1/2 N_S ~ 250evts

M_{top} = 174.0 ± 2.2(stat.) ± 4.5 (JES) ± 1.7(syst.) GeV/c^2

Mixed technique:ME to extract a Template

Kin+dynam cuts + b-tag S/B~1/1 N_S~30evts





Use dijets to constrain the JES

Precision measurements in a difficult channel!!

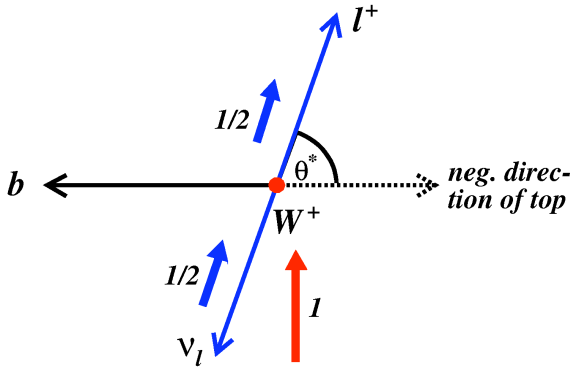
M_{top} = 171.1 ± 2.8 (stat.) ± 2.4 (JES) ± 2.1(syst.) GeV/c^2

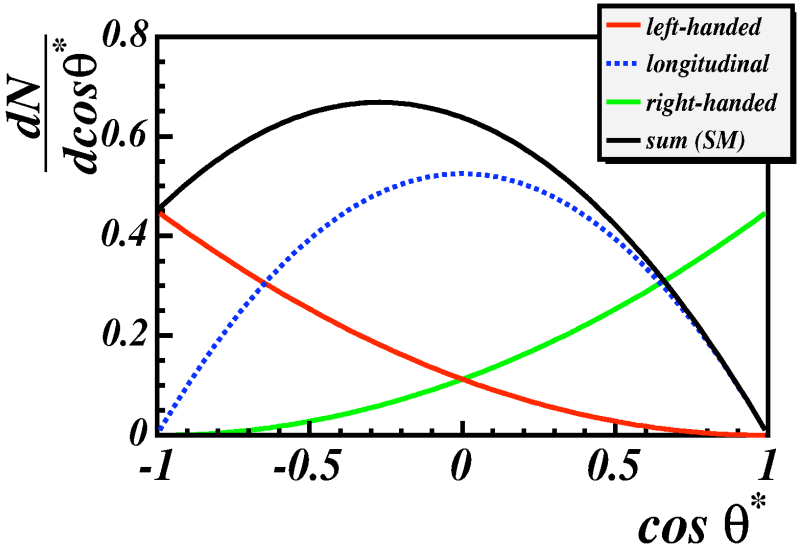
W helicity in top decays

Tests V-A interaction

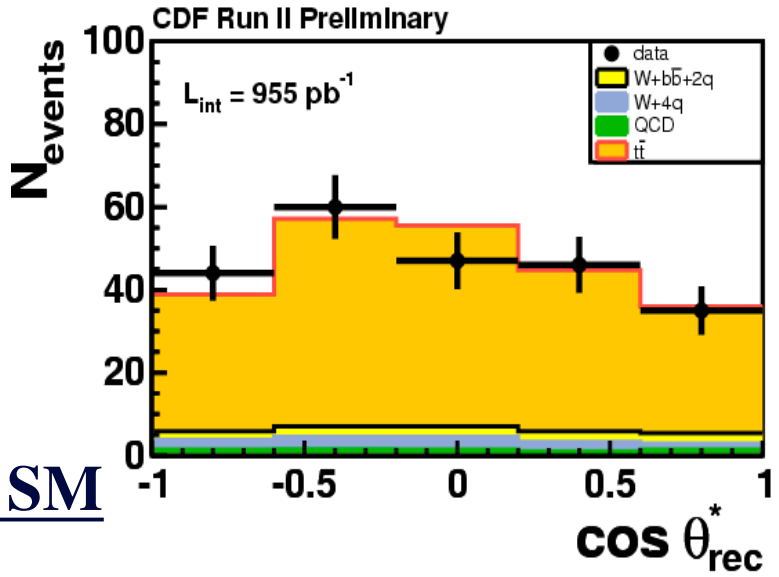
Measure the W's helicity fraction using cosθ*

SM predicts $F_0=0.7$ $F_-=0.3$ $F_+=0$





Use l+jets evts, reconstruct event kinematics



$F_0 = 0.59 \pm 0.12$ (stat.) ± 0.07 (syst.)

$F_+ = -0.03 \pm 0.06$ (stat.) ± 0.04 (syst.)

$F_+ < 0.1$ @ 95 C.L.

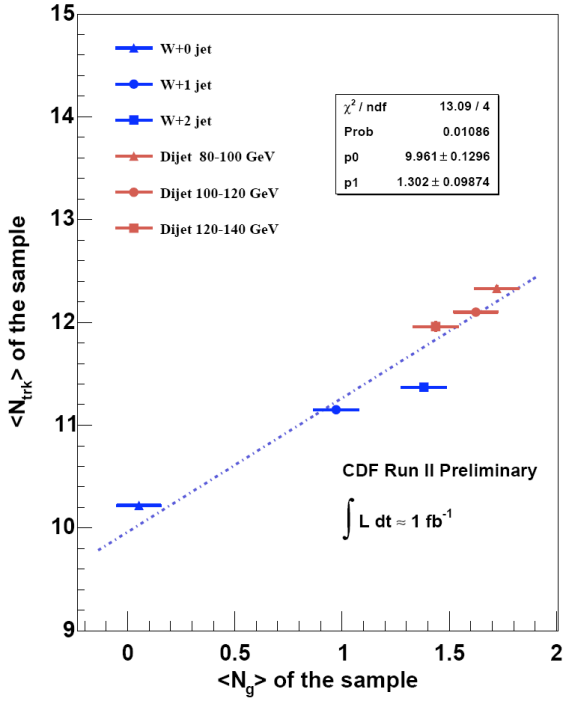
Large uncertainties but consistent with SM

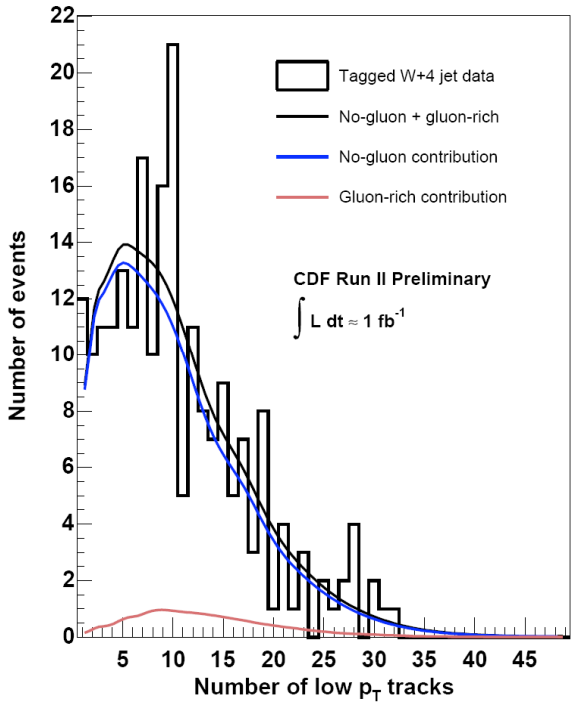
Pair production mechanism: gg vs. qq

Test of pQCD (~15% gg→ttbar, ~85% qqbar →ttbar) and is sensitive to new physics.

Multiplicity of low pt tracks is correlated to gluon content.

Data driven technique





Calibrate $\langle N_{trk} \rangle$ vs. $\langle N_g \rangle$ using W+jets and dijet data (and MC)

Fit data to **gluon rich** and **no-gluon** $\langle N_{trk} \rangle$ templates

$\sigma(gg \rightarrow tt)/\sigma(pp \rightarrow tt) = 0.01 \pm 0.16(stat.) \pm 0.07(syst.)$

New physics in top sector: resonance?

Top as a probe for new physics at very high mass scale!

Look for a heavy neutral boson with the same couplings as the Z^0

$$p\bar{p} \rightarrow X^0 \rightarrow t\bar{t}$$

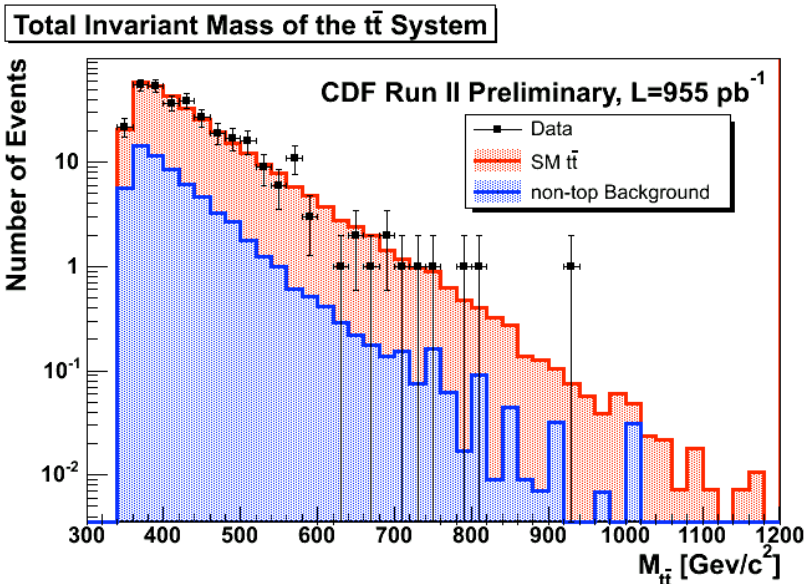
$450 < M_X < 900$ GeV/c^2

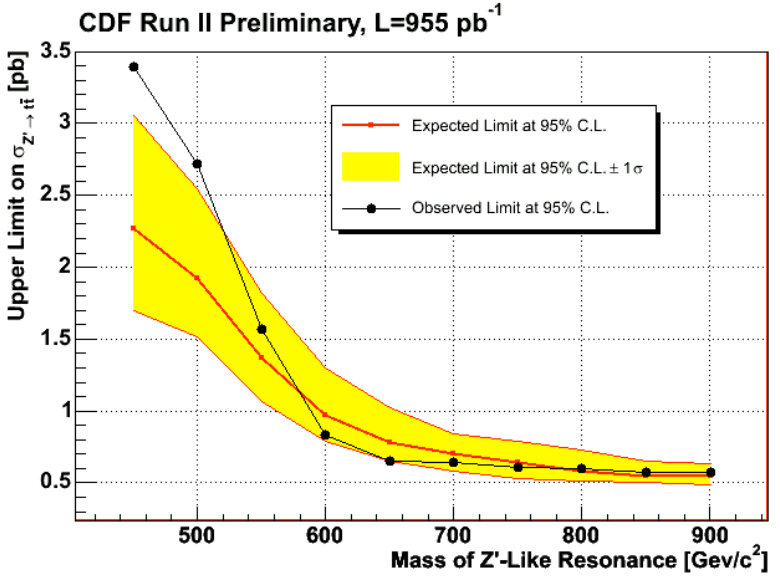
- **signal shape is totally dominated by resolution and combinatoric effects**

Fully reconstruct the event:

look for invariant mass in the t-tbar system through binned likelihood fit

Set limits to σ x BR(X^0)->ttbar





Summary of CDF analysis

SM Observable	CDF measurements	SM expectation
Mass (GeV/c^2)	170.9 ± 2.4	178^{+12}_{-9}
σ_{tt} (pb)	7.3 ± 0.9	6.7 ± 0.9
F_0	0.59 ± 0.14	0.70
F_+	<0.1 @ 95% C.L.	0
$\sigma(gg \rightarrow tt)/\sigma(pp \rightarrow tt)$	$0.01 \pm 0.16 \pm 0.07$	0.15
c x top lifetime (μm)	$c\tau_{top} < 52.5$	10^{-10}
σ(single top) (pb)	not there yet	2.9 ± 0.4

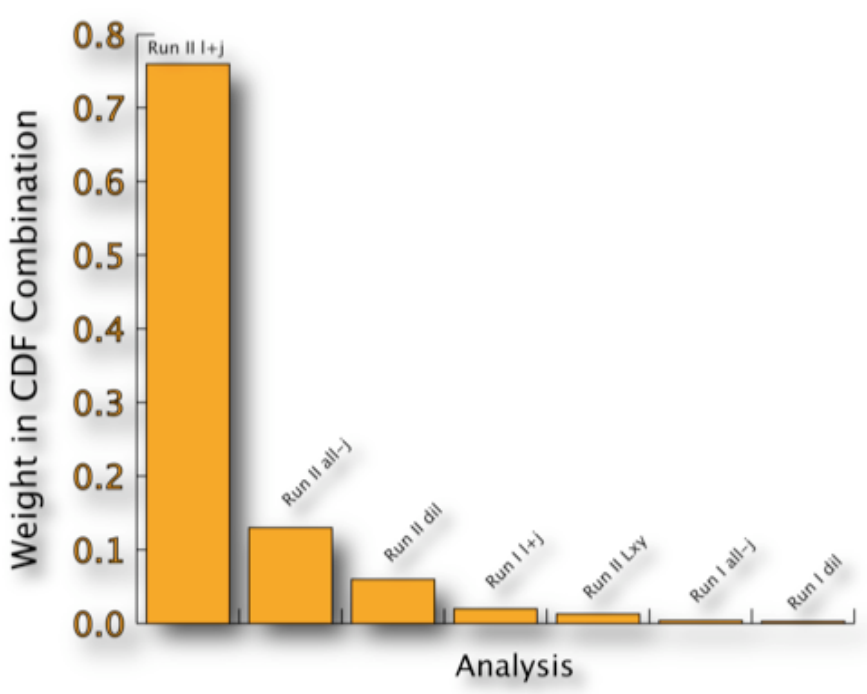
Non SM process	CDF limits
resonant production	(BR x σ) < 1 pb @ 95 C.L. for $M_X > 600$GeV/c^2
t' search	t' mass > 258 GeV at 95% CL

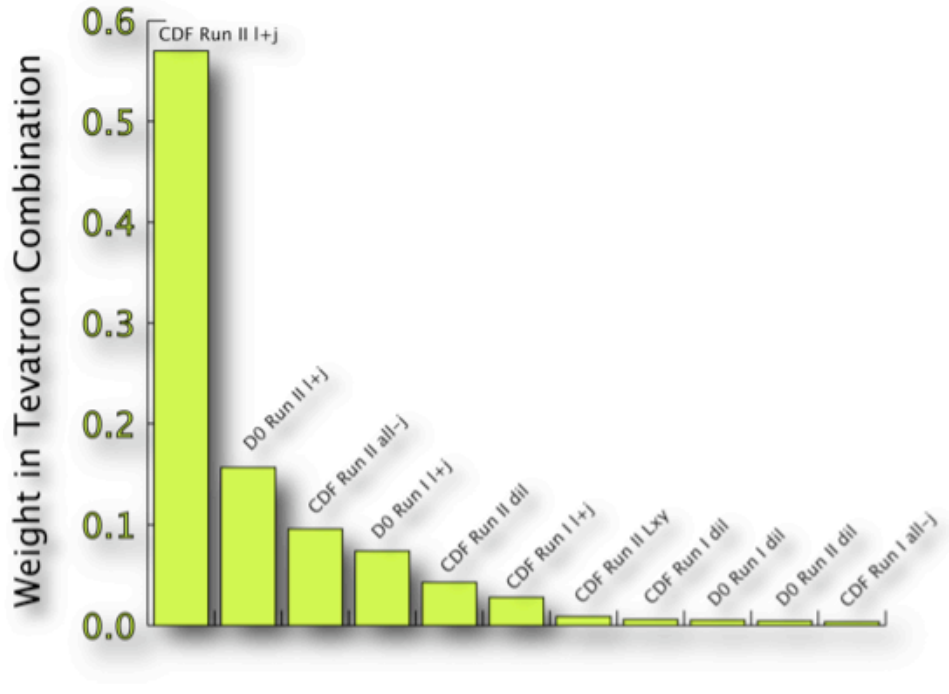
And many more.....!

BACK UP SLIDES

CDF and Tevatron mass average

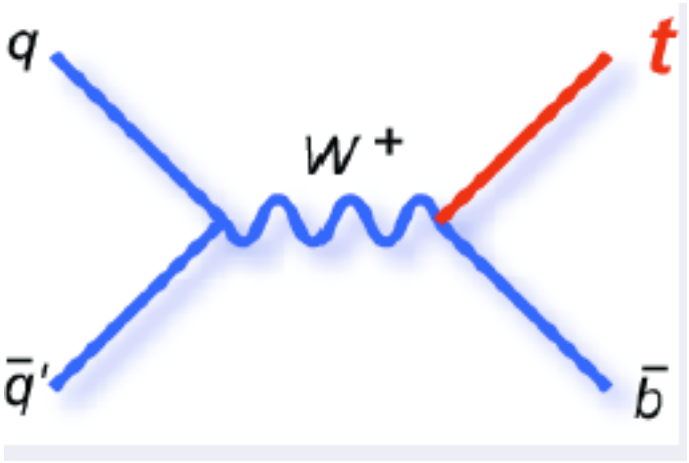
Weights of the various decay channels in the CDF and Tevatron combination:

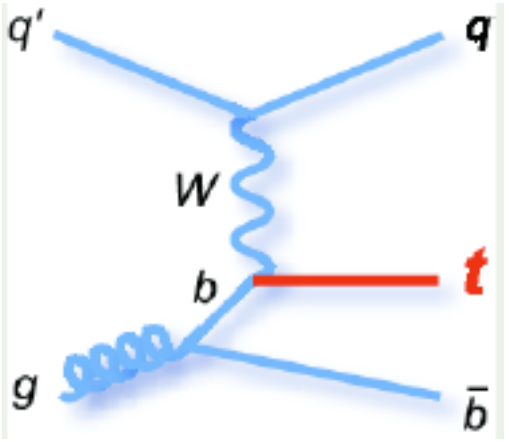




Best measurements from l+jets; second best from all-hadronic channel, third from dilepton. Trend is well-estabilished @ CDF

Single top





- Single top production probes V_{tb} and is sensitive new physics
- background to Higgs searches

Difficult signature: after evts selection on average S/B~1/30

4 different measurements:

Neural Network s+t channel <2.6 pb @ 95% C.L.

t-channel = 0.2 +1.1 -0.2 pb s-channel = 0.7 +1.5 -0.7 pb

Multivariate Likelihood Function s+t channel <2.7 pb @ 95% C.L. best fit

t-channel = 0.2 pb s-channel = 0.1 pb

Matrix Element Discriminant s+t channel = 2.7 +1.5 -1.3 pb

obs p-value(1-CL_b)=1.0% (2.3 sigma)